U.S. EPA TECHNICAL SUPPORT PROJECT
TECHNICAL SESSION SUMMARY

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Technical Support Project

U.S. EPA TECHNICAL SUPPORT PROJECT CO-CHAIRS

Engineering Forum:
Sharon Hayes, Region 1 • William Rothenmeyer, Region 8 • Neil Thompson, Region 10

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Federal Facilities Forum:
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FIELD TRIP TO THE U.S. EPA'S GULF ECOLOGY DIVISION LABORATORY

Welcome and Overview

Rick Greene, U.S. EPA, National Health and Environmental Effects Laboratory, Gulf Ecology Division

Rick Greene, Branch Chief of the Gulf Ecology Division (GED), provided an overview of GED's current mission and research activities. The GED's mission is to conduct research leading to a better understanding of the physical, chemical, and biological dynamics of coastal systems. Research findings are used to assess environmental conditions, determine the causes of existing conditions, predict future risks, and establish criteria for protecting the environment. Specific goals of the GED are to:

- Assess the ecological condition of estuaries, coastal wetlands, submerged aquatic vegetation, and coral reefs of the Gulf of Mexico,
- Determine the cause(s) of ecological impairment,
- Predict future risk to populations, communities, and ecosystems from multiple aquatic stressors such as nutrients, toxic chemicals, harmful/nuisance algal blooms, pathogens/disease, critical/threatened habitat, and suspended sediments,
- Support the development of criteria to protect coastal environments, and
- Transfer scientific technology to federal and state agencies, industry, and the public.

GED's activities and organizational structure have been modified over the past few years to reflect changes in EPA research priorities, workload allocations, and funding. Research at the GED is conducted by five teams:

The ***Ecosystem Assessment Team*** conducts research to develop, validate, and integrate approaches and methodologies for assessing ecological conditions of estuarine and coastal waters of the United States. John Macauley (available at 850-934-9353 or macauley.john@epa.gov) leads this team. Priority tasks for the team include the:

- planning, design, and oversight of coastal programs for the EMAP western pilot, national coastal assessment, Gulf of Mexico, and indicator development research,
- development of a diagnostic framework for the assessment of aquatic and estuarine resources in Pensacola Bay, Escambia Bay, and Escambia River systems research, and
- aquatic mortality tracking research.

The ***Nutrient Research Team*** conducts research to provide regulators with information needed to set criteria for estuarine and coastal waters, understand nutrient processing in these water systems, develop tools for identifying the cause/effect relationships between nutrient enrichment and eutrophication, and understand how these relationships are controlled by physical, chemical, and biological factors. Dr. Emilie Lores (available at 850-934-9238 or lores.emile@epa.gov) leads this team. Priority tasks for the team include the:

- dissolved oxygen response to nutrients causes and effects research,
- development of submerged aquatic vegetation (SAV) loss-nutrient load relationships and factors which control SAV response to nutrients research, and
- effects of nutrient loading on food web structure, dynamics, and ascendancy in coastal receiving waters research.

The ***Global Change Research Team*** conducts research for characterizing the effects of global change stressors on coral and coral reef ecosystem health. Dr. William Fisher (available at 850-934-9394 or fisher.william@epa.gov) leads this team. Priority tasks include the:

- coral disease and mortality research,
- effects of temperature and UV radiation on corals research, and
- effects of temperature and UV on coral symbionts research.

The ***Ecological Risk Research Team*** conducts research for determining the reproductive and developmental responses of estuarine organisms to environmental stressors, and for quantifying those responses as indicators of the population conditions. Dr. Michael Hemmer (available at 850-934-9243 or hemmer.michael@epa.gov) leads this team. Priority tasks include the:

- influence of xenobiotic chemicals on physiological performance of estuarine crustaceans research, and
- development of amplified fragment length polymorphism markers to assess genetic diversity of estuarine fish species research.

The ***Ecological Futures Team*** conducts short-term research to respond directly to EPA regional or program office needs and to address emerging environmental issues. Dr. Fred Genthner (available at 850-934-9342 or genthner.fred@epa.gov) leads this team. Priority tasks include the:

- altered habitat research,
- indicators, pathogens, and environmental quality of beaches and near-coastal waters research,
- refinement of the bivalve sediment toxicity test research,
- development and validation of predictive phytotoxicity bioassays and in-situ assays as useful tools for near-coastal hazard evaluations research,
- biochemistry and molecular biology of toxic cyanobacteria: growth requirements; regulation of development and dioxin production; biochemistry of toxin biosynthesis research,
- small fish carcinogenesis models research, and
- predicting contaminant effects research.

Diver Training Program

Jed Campbell, National Health and Environmental Effects Laboratory, Gulf Ecology Division

Jed Campbell of the EPA's Diver Training Program, noted that EPA has been providing support to other EPA offices, federal agencies, and state/local governmental organizations for scientific diving efforts since 1984. EPA's National Diver Training Center, housed at the GED campus in Gulf Breeze, has trained and certified more than 400 divers. Training elements include diving accident management, oxygen-enriched air diving, polluted water diving, surface-supply diving, polluted-water diving, divemaster specifications, and principals in scientific diving.

EPA diving units conducts over 2,000 dives annually in support of a variety of projects such as surveying coral disease, assisting the U.S. Coast Guard in locating lost drums containing arsenic, and studying ocean dumping/dredging sites off Florida, Georgia, and North Carolina. Diving units also have conducted sampling and research activities, including the sampling of hazardous waste drums located within Torch Lake, MI, oxygen demand/nutrient transfer studies in contaminated sediment, and in-situ benthic recolonization experiments. EPA divers conduct specialized activities involving cold-water diving (such as the past inspection of an illegal dump site used for fish processing in Alaska) and contaminated-water diving (such as the locating of 1,200 hazardous waste drums in an abandoned rock quarry in Indiana). More information is available from Jim Patrick, EPA Diver Training Director, at 850-934-9242 or patrick.jim@epa.gov.

Facility Tour

Following the presentations, research staff provided TSP members with an in-depth tour of the specialized laboratory facilities located at the Gulf Breeze campus. These facilities included the Aquatic Toxicology Facility, Harmful Algal Bloom Laboratory, Histo-Pathology Laboratory, Nutrient Laboratory, Molecular Ecology Laboratory, and the Coral Culture Facility. (Additional information on the GED is available from William Benson at 850-934-9208 or benson.william@epa.gov. Various GED publications are available directly from the GED web site at www.epa.gov/ged.

NOVEMBER 19, 2002

PRESENTATIONS BY THE U.S. ARMY CORPS OF ENGINEERS (USACE), WATERWAYS EXPERIMENT STATION

Evaluation of Contaminated Sediment Sites and Guidance for Environmental Dredging

Dr. Mike Palermo, U.S. Army Corps of Engineers, Waterways Experiment Station

Dr. Mike Palermo presented USACE's perspectives on contaminated sediment remediation and discussed considerations for effective environmental dredging and sediment remedies. As part of its mandate to maintain the navigability of our nation's waterways and harbors, USACE dredges over 300 million cubic yards of sediment each year. Dr. Palermo refers to sediments as "the fourth environmental medium," noting that sediments present unique challenges and properties that set them apart from soil, air, and water. Dredging for USACE's navigation program is primarily influenced by economic considerations, while environmental dredging projects are fundamentally concerned with environmental impacts. Although they have been dredging for over 150 years, USACE has been conducting sediment management planning and research for only 30 years. WES coordinates a number of sediment research programs, including the Center for Contaminated Sediments, Dredging Operations and Environmental Research (DOER), Long-Term Effects of Dredging Operations (LEDO), and Dredging Operations Technical Support (DOTS).

As a "federal engineer," USACE provides support to CERCLA by assisting with technical planning and design, environmental evaluations, management and oversight of design, contracting and construction management, and monitoring. Dr. Palermo discussed the relative advantages and disadvantages of a number of sediment remediation alternatives, including monitored natural recovery, in-situ capping, in-situ treatment, dredging with containment, and dredging with treatment and disposal. USACE, EPA, the National Oceanic and Atmospheric Administration, the Remediation Technologies Development Forum, and the Navy have been drafting a joint agency guidance on evaluating and managing contaminated sediment sites.

The goal of environmental dredging is to meet remedial action objectives (RAOs), remediation goals (RGs), and cleanup levels (CULs). Great care must be taken when choosing a dredge, as certain dredges are better suited for environmental work than others. All dredges resuspend some sediment, but resuspension can be minimized by carefully evaluating the physical characteristics of the sediments and the nature of the contaminants. The depth, quantity of sediment to be removed, distance to disposal area, method of disposal, and the presence or absence of debris are all important factors that must be taken into consideration when choosing a dredge. Once a dredge has been selected, process considerations include horizontal and vertical tolerances, sediment resuspension, contaminant release, efficiency of removal, and compatibility with treatment and/or disposal. Properly managed operations and the selection of an appropriate dredging rig can minimize contaminated sediment resuspension. USACE has conducted field evaluations of both conventional dredges and equipment specifically tailored for remedial dredging. In addition, they have refined their predictive capability by developing computer models, such as SSFATE, that assist in planning for and conducting environmental dredging.

Dr. Palermo concluded his presentation by discussing considerations for effective sediment remedies. His 10 principles for effective sediment remedies include the following tenets:

- all decisions should be risk-based;
- sources must be controlled;
- set realistic RAOs, RGs, and CULs;

- compare effectiveness of options on an equal footing;
- evaluate spatial and temporal aspects of exposure;
- tailor operations to achieve short-term effectiveness;
- design for long-term effectiveness and permanence;
- develop site-specific, project specific, and sediment specific remedies;
- optimize effectiveness by combing options; and
- monitor to document effectiveness.

He noted that EPA's Office of Emergency and Remedial Response is in the process of drafting technical guidance for environmental dredging. In conclusion, there is no universal solution for removing contaminated sediments. Careful planning and the selection of appropriate equipment will minimize the impact of contaminated sediment resuspension. For more information on WES's capabilities and expertise, visit their website at http://www.wes.army.mil/el/dots/ccs/index.html.

Questions and Answers

Question: Have you done any work with sorptive caps?
Answer: Yes, we have looked at the performance of a few sorptive caps, including one in Seattle and another on the Anacostia River in Washington, DC. Most sorptive caps have not been implemented on a wide-scale.

Question: How do PRPs react to the predictive capability of models?
Answer: Models are tools that can be used to help make decisions. No models are perfect, but they can be a useful component of the design and remediation process. Everyone, including PRPs, uses models, but the results of different models can vary significantly.

Question: Has there been any talk of institutional control (IC) monitoring?
Answer: Most projects incorporate ICs, and monitoring them is an important component of the remedy. OERR's new sediment guidance document contains a chapter on ICs.

Question: PRPs think that worker safety at dredge sites can be compromised, as dredging has a reputation for being more dangerous than other remedies. Is it more dangerous?
Answer: Dredging certainly poses risks to worker safety, but when done correctly, the safety record is no worse than for other construction projects.

Question: Why not select cutter head hydraulic dredges rather than traditional clam shell mechanical dredges, as the former traditionally resuspends less sediment than the latter?
Answer: The mechanical dredges in operation today are much better than those that were used in the early 80s, when they got a bad reputation for resuspending sediment.

Question: Have you seen much cap recontamination, where monitoring has been done?
Answer: We haven't seen much recontamination from below the cap, but contaminants have settled on top of the cap that came from the surface or adjacent contaminated areas.

Question: Is there a guidance on long-term monitoring?
Answer: Yes, our guidance documents on capping include information on long-term cap monitoring and can be found at WES's website (http://www.wes.army.mil/).

To view Dr. Palermo's presentation materials for details, click here.

Fate and Transport of Explosives in Soil and Ground Water

Judy Pennington, U.S. Army Corps of Engineers, Waterways Experiment Station

Judy Pennington discussed the transport properties of explosive compounds in the environment. She explained that explosives in the environment are primarily a result of Department of Defense (DoD) activities, although mining and other commercial activities account for some of the contamination. Much of the existing explosives contamination occurred during World War II when there was little awareness or concern for polluting the environment. Since the 1980s, the focus of cleanup efforts has been manufacturing and "load-and-pack" sites where the rounds of munitions were filled with explosives. These sites produced the most significant sources of explosives contamination.

In 1995, RDX was discovered in ground water at the Massachusetts Military Reservation. This was a wake-up call for DoD, who needed to know if the contamination is controllable. Explosives contamination is an issue that affects all of the EPA regions. At old manufacturing and load-and-pack sites, the cause of contamination was almost always washdown, so the explosives were in solution form when they were discharged to the soil. At live-fire sites, contamination was discharged in a solid form with duds and misfires that left behind residues. Dissolution of explosives from solid sources is low; therefore, live-fire ranges are less significant sources of ground-water contamination.

The most common explosives compounds found are TNT, RDX, HMX, and others that include picric acid and PETN. Ms. Pennington explained the differences in the chemical and transport properties of TNT and RDX. TNT is unstable in the environment and transforms to mono amino products in reducing conditions. TNT tends to be attenuated by soil and is transported to ground water only when the volume of contamination exceeds the capacity of the soil to attenuate it. RDX, on the other hand, is readily transported from soil to ground water. Therefore, it can be found in ground water at a wider range of sites than TNT.

Ms. Pennington summarized a 3-year monitored natural attenuation (MNA) project conducted at the Louisiana Army Ammunition Plant. The source soils, which contained RDX, TNT, TNB, and HMX, were excavated and incinerated; the ground water was treated with activated carbon. Monitoring wells were installed and 30 were monitored over 3 years. Concentrations of explosives in most wells were shown to decline with time. Modeling of the site also showed a significant decrease in the size of the plume in 20 years. Ms. Pennington explained the advantages and limitations of MNA and added that the use of MNA at a site will depend on the residence time and proximity of receptors.

She concluded her presentation by noting the effects of explosives on vegetation and animals. TNT tends to become bound up in the roots of plants. The bioavailability of TNT is governed by soil properties, especially organic carbon content. TNT is not bioavailable in clay soils. RDX, on the other hand, is readily take into the leaves and fruits of a plant and bioaccumulates. The toxicity of explosives varies with animal species, and the toxicity data are limited. TNT is typically more toxic than RDX, and its transformation products can be more toxic than TNT. It is possible that mammals may be more sensitive to explosives than birds or amphibians.

Questions and Answers

Question: In terms of source control, where is the best place to look for explosives contamination in soil? How big are residual sources?
Answer: You must research the facility, including looking at the historical record (especially if it's a FUDS). It is important to determine where the buildings used to be on the property and to interview

former staff. The only way to find solids at a load-and-pack site is the unlikely scenario of losing enough water to get recrystallization of the compounds.

To view Ms. Pennington's presentation materials for details, click here.

CAPTURE ZONE PRESENTATIONS

Illustrated Examples of Capture Zones in Porous Media at Pump and Treat Sites

Rob Greenwald, Yan Zhang, and Doug Sutton, GeoTrans, Inc.

Rob Greenwald, Yan Zhang, and Doug Sutton introduced the "how to" guidance on capture zone analysis that GeoTrans, Inc. is preparing. They hope to have a draft of the guidance ready for review by the end of this year.

In their examination of existing pump and treat sites, GeoTrans has found that interpreting capture zones is difficult at best and vertical capture is almost always ignored. Capture zone examples in EPA documents have typically been limited to two-dimensional, simple systems. In the remediation systems evaluation of 20 sites, at least 14 sites had not defined the capture zone; 10 had not evaluated whether the system had achieved the capture zone; two sites had no water elevation data; and eight sites used ground-water flow models, but they were not necessarily being used to evaluate the capture zone. In evaluating capture zones, there is no one argument to prove that capture has or has not been achieved, but rather evaluation should be done using the concept of converging lines of evidence.

The structure of the draft guidance will be as follows:

- Begin by describing the six basic steps of capture zone analysis.
- Present three hypothetical case study sites of varying complexity to illustrate the proper use of techniques.
- Highlight typical errors in capture zone analysis and show how making these errors can change the interpreted capture zone.

The guide will not address capture zones in fractured rock or karst. The six basic steps of capture zone analysis in the guidance will be:

1. Thoroughly define prerequisites—plume is adequately delineated, there is adequate information on hydraulic conductivity, gradient, and aquifer thickness, and the remedy goal is clearly stated.
2. Define target capture zone(s). Is hydraulic capture required horizontally and/or vertically? Are there additional conditions that should be met?
3. Perform a flow budget calculation and/or analytical solution. Note that these calculations or analytical solutions do not take into account vertical capture. While these may be done as part of a capture zone analysis, there is a large amount of uncertainty in the values being used in the computations, and the results should only be used as part of the lines of evidence.
4. Interpret water level maps. Are the number and distribution of monitoring wells adequate? Are water levels in the vicinity of the extraction wells included? (Levels in the pumping wells should not be used.) Has horizontal capture for all horizontal layers been evaluated? Has the potential for vertical flow been taken into account? Are there any biases in contouring software algorithms? Have transient influences such as precipitation been included?
5. Perform site-specific supporting lines of evidence evaluation, e.g., head difference patterns at water level pairs, concentration trends at monitoring wells, and particle tracking results from numerical flow models.

6. Interpret actual capture and compare to target capture zone(s).

The guidance provides three site examples. These examples were developed to illustrate the six steps for capture zone analysis presented above and to highlight some of the details associated with the techniques for evaluating capture. The examples are each represented by a numerical flow and transport model that is intended to portray "actual conditions". Each example has a different degree of complexity, to represent a variety of real world conditions.

Site 1: An RDX source at Site 1 has been removed. There is a heterogenous, but horizontal, subsurface with preferential pathways. The remedial goal is to have horizontal containment at the property line.

Site 2: There are several continuing sources of TCE at Site 2. The stratigraphy consists of a shallow aquifer overlying a discontinuous aquitard beneath which lies the regional aquifer. The property is not located close to any surface water bodies. The aquifers are relatively homogeneous in the area where the property is. The remedial goal is containment at the property boundary with capture wells in the shallow zone.

Site 3: Site 3 has a continuous TCE source and contaminated ground water discharging to a river. The subsurface contains a shallow aquifer and a deep aquifer with heterogeneous hydraulic conductivity distribution. There is some contamination in the deep aquifer. A water supply well is located in deep aquifer on the other side of the river. This well disrupts the normal flow into the river and causes some underflow of contaminants. The goal is to prevent contaminants at concentrations above standards from discharging to the river and from flowing under the river to the water supply well.

There are two options to define target capture zone for Site 3. One is horizontal hydraulic containment with vertical migration allowed as long as concentration is less than standard for the flow under the river. The other one is hydraulic containment both horizontally and vertically. Three pumping scenarios were evaluated for these two target capture zone options with varied pumping wells and rates. The analyses indicate that the scenario satisfying the more strict goals (both horizontal and vertical containment) has much larger pumping rate and more pumping wells and therefore higher cost.

Site 3 has a range of hydraulic conductivity values; however, the analytical calculation calls for one. The highest value can be used, but this approach will produce a very conservative estimate. A representative (middle range) value can also be used, but this approach may underestimate the required pumping. Several calculations using different conductivities may be called for; however, the actual calculations do not take long. Also, aquifer thickness is another complication. The saturated thickness is variable and depends on the actual water level because of the unconfined shallow aquifer. The extraction wells are only screened in the upper horizon of the shallow aquifer, but the wells likely draw water from all horizons of the shallow aquifer, and perhaps from the deep aquifer as well because there is no aquitard separating the shallow and deep aquifers.

Using water levels at or near r the extraction wells makes a big difference in interpretation of capture zone. It is generally not a good idea to use water level measurement in the actual pumping well for water level interpretation due to well losses. It is best to install a piezometer near each extraction well, but when that is not possible, it is better to estimate aquifer water levels at the extraction wells (subtracting out estimated well losses) than to exclude such data points together.

The interpretation of water level maps may vary for different contouring methods or algorithms, leading to alternate interpretation of capture. Interpretation of capture based on concentration trends at monitoring wells located downgradient of the target capture zone is complicated by expensive cost, long term duration (years), and multiple hydrogeologic units. Additional complication is the locations of the monitoring wells. If the monitoring well is located within the capture zone, the concentration trend can not be used for interpretation of capture zone. Also, a declining concentration over time may be observed at early time even for cases where capture actually fails. However, to determine if a monitoring well is in an appropriate location, it requires prior knowledge of the actual capture zone extent, which in fact is not known.

If a calibrated ground-water flow model has been developed for the site, particle tracking can be applied to provide a precise delineation of hydraulic capture horizontally and/or vertically. However, the capture zone indicated by the particle tracking is only as accurate as the underlying water elevation predictions from the flow model, which are subject to many types of uncertainty.

Questions and Answers

Question: Will the guidance explain how to choose the "fudge" factor for the flow budget calculation?
Answer: No. The "fudge" factor, whether it is the rule-of-thumb of 1.5-2 or other, is designed to estimate the order of volume of water that will need to be moved. An exact number isn't necessary.

Question: Will the guidance indicate the head difference needed in the monitoring wells during pumping to indicate capture in a model?
Answer: The guidance will discuss the issue in terms of conservatism, but will not provide hard numbers to use.

Question: When is the stabilization of contaminant concentrations in monitoring wells an appropriate measure for adequate capture zone determination?
Answer: There are a number of examples where declining or stabilized concentrations may stop at levels above the action level, which implies that the plume is not being captured. The monitoring well location is also important since it has to be located outside the capture zone to provide valid data.

Question: Is there any value to preparing drawdown maps?
Answer: Drawdown maps will overestimate the capture zone. However they are a valuable tool in evaluating heterogeneities at the site.

Question: If you need to optimize the pumping rate to treat as little water as possible and still be effective, what would you do?
Answer: If you want to "see" the capture zone you may have to pump at a much higher rate than is optimal. Setting the pumping rate at a value that just captures the plume will require that a much larger effort be put into validating the model used to predict the zone, because only a model can really predict the zone location and it will definitely have uncertainties.

To view GeoTran's presentation materials for details, click here.

Capture Zone Evaluation for DNAPLs in Fractured Rock: A Case Study

Dr. Dick Harlan, Harlan & Associates, Inc.

Dr. Harlan detailed the ongoing work to remove DNAPL from fractured bedrock at a site outside of Boulder, Colorado. In 1991, a park ranger discovered a natural seep containing an orange precipitate. The Colorado DPHE sampled the seep and discovered *cis*-1,2-DCE and vinyl chloride. The plume was

traced back to the clean room annex area of the Former Beech Boulder Facility. A clay-lined impoundment in this area once received washdown water, solvents, and electroplating wastes.

The open space at the site was purchased by the City of Boulder, and the main facility, which manufactured drone aircrafts from the 1960s to 1987, was purchased by a land developer. The State of Colorado's proposed final use for the property is unrestricted residential, which could entail the use of onsite water supply wells; however, Dr. Harlan noted that the water would not be potable, regardless of the DNAPL contamination, due to the presence of natural hydrocarbons in the underlying formations.

The site is underlain by the Cretaceous Niobrara Formation. The lowermost member of the Niobrara is the Fort Hays Limestone. A series of limestone hogback ridges that dip to the east toward a regional discharge area are present at the site. The impoundment mentioned above was situated above a structural syncline, and the solvents discharged to the impoundment desiccated the underlying shale resulting in an increase in fracture permeability. The impoundment was later replaced with tanks. But when the clean room annex burned down in the early 1980s, some of the tanks ruptured.

A well drilled downgradient of the impoundment detected high concentrations of TCE, *cis*-1,2-DCE, vinyl chloride, freon, and acetone. The highest total VOC measurement was 1,200 ppm. A telescoped well drilled in the impoundment showed that total VOC concentrations decrease with depth. VOC concentrations in the unnamed drainage area (near the seeps) ranged up to several thousand ppb, although concentrations decrease by several orders of magnitude downgradient.

In 1995, interim remedial measures were implemented by installing eight extraction wells in the impoundment area for hydraulic containment and source removal. The extractions wells pump at less than 1 gpm with 40 to 50 feet of drawdown and a radius of influence of 20 to 25 feet. The wells remove about 60 pounds of solvent per quarter. To date, 3,000 pounds have been removed.

Shut-in tests at the extraction wells showed no affect on the water table in instrumented wells within 30 feet of the extraction wells. The wells responded, however, to precipitation events, which is typical of a fractured rock environment. Wells screened within the Fort Hays member of the Niobrara Formation did not show a response to the shut-in test, but responded to barometric pressure changes, which is not typical of an unconfined aquifer. Another unusual observation was that water levels in wells at the downgradient edge of the extraction well system continued to drop after the extraction wells were turned off. In conclusion, there was a high degree of variability in response to the shut-in tests, due to the fractured rock setting. There is a great seasonal flux in water levels, which is why greater concentrations of contaminants have been observed.

The complex geology at the site requires complex remediation. Source removal is ongoing, and the water table is being suppressed to enhance SVE.

Questions and Answers

Question: Could tracers be used at this site to help in the fractured rock investigation?
Answer: Yes, but the success of using tracer depends on the rates of migration and where the monitoring wells are located.

Question: Did you measure the hydraulic conductivity and transmissivity of the formation?
Answer: The rock matrix is essentially impermeable due to infilling as a result of secondary mineralization. The only permeability is due to the presence of fractures and is highly variable.

However, the Fort Hays Limestone, must have a high hydraulic conductivity due to the uniform response exhibited throughout the clean room annex area.

Question: Did you conduct surface and borehole geophysics at the site?
Answer: We used reflection and refraction to define subsurface structures, but the effort failed because there was insufficient velocity contrast between units to yield clear results. Borehole geophysics helped determine where the fractures were and their orientations. Borehole geophysics did not help save money, however, due to the higher costs of coring rather than air hammer drilling.

Question: A lobe of the plume crosses the hinge of the anticline. Could there be a second source for the plume?
Answer: A second source is possible. Water levels in the Fort Hays Limestone fluctuate 40 feet in the syncline seasonally. It's possible that the barrier is also a conduit, and leakage occurs upward into the unnamed drainage. If water levels rise seasonally then drop, there must be a point of discharge.

To view Dr. Harlan's presentation materials for details, click here.

NOVEMBER 20, 2002

DNAPL SEMINAR

Times Scales of DNAPL Migration Dr. Bernard Kueper, Queen's University

Dense non-aqueous phase liquids (DNAPLs), which have densities that are typically between 1050 kg/m^3 and 1600 kg/m^3 are generally immiscible in water. Water solubilities of DNAPLs generally range between 20 mg/L and 2000 mg/L, and viscosities range from 0.5 cP to 100 cP. Chlorinated solvents are at one end of the mobility spectrum (lower viscosity and higher density), and creosotes and coal tars are at the other (higher viscosity and lower density). PCB mixtures lie in between.

A release of DNAPL may result in subsurface vapors, residuals (globules of material trapped by capillary forces), and pools (operationally defined as connected through pore space) of organic liquid that can move. If ground water is encountered, there may be a dissolved phase as well.

Understanding DNAPL movement is important because it can influence remediation decisions and costs. Dr. Kueper provided a couple of examples of how, under certain circumstances, DNAPLs can continue to move many years after their initial release. He mentioned a Louisiana facility with a large pool of DNAPL that has been resting on a clay aquitard for many years with a regional aquifer lying about 200 feet below the aquitard. A water flood remedial action was implemented to reduce the DNAPL to a residual phase to avoid the risk of it moving. A Laramie, WY, creosote site with a large DNAPL pool (1,000-ft by 2,000-ft by 1-ft-thick) has also implemented a water flooding system to remove free-phase DNAPL to reduce it to residuals so it does not move as a free-flowing mass. This DNAPL had been present for years and was thought to be moving downward very slowly along shallow dipping fractures in a siltstone bedrock.

A controlled release experiment was conducted in the late 1980s by discharging about 1½ drums of PCE into the Borden Aquifer. The DNAPL was monitored to determine how long it took to stop moving. A 1-cm silt layer caused pooling of the DNAPL atop the silt, and the DNAPL stopped moving after about 2 to 3 weeks. Because the PCE was dyed, excavation of the area allowed visual identification of residuals and pools. The patterns of migration showed that it did not take much of a change in permeability to influence the flow pathway of the PCE.

The factors influencing the timescales of DNAPL migration include:

- fluid density
- fluid viscosity
- DNAPL-water interfacial tension
- medium permeability and structure
- volume/duration of release
- hydraulic gradient
- capillary and relative permeability properties

All things being equal, with no hydraulic gradient, some DNAPLs take longer than others to migrate downwards through a 100-foot-long, water-filled, vertical fracture. For TCE, the calculated migration time would be on the order of one-third of a year; for coal tar, migration would take about 100 years. In Dr. Kueper's experience, coal tar DNAPL continues to move for long periods of time. At wood treating sites where the plant has been closed for years, DNAPL may still be moving into surface water sediments and forming sheens on the water. This would not occur if the coal tar was not still moving.

The continued flux of contamination generally is not observed at solvent sites where the mobility is typically much higher.

Using a model that considers aperture width, fracture depth, matrix porosity, fracture dip, and five different solvents, how long would it take for a DNAPL to migrate through a 3-meter-long fracture and a 10-meter-long fracture that are in a saturated clay matrix with minimal hydraulic gradient? The model predicts that fracture width is the most influential of the parameters, with the matrix porosity and diffusion having little effect. Even for the smallest aperture (15 μm), breakthrough for the 10-meter fracture for all chemicals considered was less than 100 days, with PCE taking less than 10 days. Therefore, chlorinated solvents will move quickly through fractures.

Very low hydraulic gradients probably do not have any influence on DNAPL migration. However, where higher gradients and lower density DNAPLs exist, the hydraulic gradient can have an influence—even to the point of forcing an upward flow. For example, assuming a negligible capillary gradient, an upward gradient of 0.46 will arrest downward flow of a TCE DNAPL, but an upward gradient of only 0.06 is required to arrest a coal tar. The principal influence on DNAPL flow is still geologic structure, but hydraulic gradient should not be ignored.

There are two additional factors that need to be considered when assessing DNAPL migration—capillary entry pressure and terminal pressure, which is the capillary pressure at the top of the pool after DNAPL movement has stopped. For a DNAPL to move, it must overcome the capillary entry pressure. During the Borden Aquifer experiment, a sufficiently high head could not be generated to overcome the capillary entry pressure of the silt layer. As a result, pooling was observed. Some general conclusions can be made with regards to DNAPL migration and capillary properties:

- DNAPL will stop moving once capillary pressures are less than entry and terminal pressures.
- DNAPLs cannot move in “perpetuity” because they will dissipate as residuals and pools. Hence, the distance (time) of migration is limited by the volume released. By inference, large volumes can mean relatively long migration times, especially with the lighter DNAPLs.

Widely different modeling results can be obtained for DNAPL migration, depending upon the assumptions made and the factors put in the model. For example, not including terminal pressure will result in a much longer migration time. The take home message is to always examine what is in, and what is *not* in, a model before accepting the results.

Significant matrix diffusion will take place in many soil and rock matrices, although not all of them. A DNAPL can impact a matrix, resulting in some capillary invasion and/or diffusion, depending upon the matrix structure. With time, the source area will dissipate to the extent that it has a lower concentration of a chemical than the matrix. This will result in a reversal of the diffusion process at the former DNAPL matrix interface. However, it will not initially stop the diffusion front within the matrix from moving forward. This will take time. This back diffusion will likely limit the time scales of remediation in many rock types (e.g., clays and some sandstones and limestones) because it will continue for a much longer time than the original forward diffusion period.

Overall conclusions that can be drawn regarding DNAPL migration include:

- The timescale of solvent DNAPL migration is relatively short in porous and fractured media because of their lower viscosities and higher density.
- The timescale of creosote/coal tar DNAPL is relatively long in porous and fractured media.

- Hysteresis and capillary entry and terminal pressure must be incorporated into numerical models designed to predict DNAPL movement time.
- Back diffusion of chemicals from bedrock/clay matrices will limit time scales of remediation.

If there is actively moving DNAPL or the potential for movement at a site to be remediated, then Dr. Kueper recommends doing a water flood as a first step to bring the material to a residual level and remove the potential for further movement. Water flooding does not apply to residuals, however, which present a different contamination/remediation problem.

Questions and Answers

Question: How important is measuring matrix porosity, especially in rock?
Answer: I recommend that porosity be measured to show whether matrix diffusion can (or cannot) happen and then use simple analytical models to see what happens. The Core Lab in Houston measures matrix diffusion for a reasonable price.

Question: There can be many fracture zones in site bedrock. Which types of fractures may be important in a DNAPL investigation?
Answer: Look at fractures along bedding planes and large vertical or sheeting fractures. Small fractures are less important. Angled borings are best for vertical fractures, and a downhole video camera is good for looking at fracture strike and dip. There is not a huge cost difference for angled drilling, but a large difference exists for angled coring or orientation core. In addition, outcrop and pavement mapping should always be done before drilling. After the downhole videos are made, the boreholes should be packer tested. The smaller the test interval of the packers, the better, because it gives a better estimate of average aperture transmissivity and bulk conductivity.

Question: Does chemical partitioning play a role in creosote and coal tar movement?
Answer: There should not be much partitioning within the DNAPL mass, but there may be preferential dissolving of materials out of the mass, which may change the mobility properties of the DNAPL. It would also depend upon the original source of the material and how it was released. The preferential dissolution will also affect how you model the dissolved fraction of the plume.

Question: Have you examined colloidal transport of DNAPLs (e.g., PCBs)?
Answer: I have not done much work in this area, although I've observed some emulsion movements at sites. It is an area that needs further investigation.

Question: Do you have any comments on surface geophysical methods for finding fracture patterns?
Answer: I have not had much luck in using geophysics for this purpose and prefer doing intrusive work with packer testing and interpreting the hydraulic head. A low head difference between boreholes in rock generally means good connections between them, for example, while a high head drop can be interpreted to mean there is little connection.

Question: If you want to remove a mobile DNAPL, could you implement the water flooding in a way that you could use it to further delineate the source?
Answer: Yes. Flooding could be done in modules. If you don't get any recovery in a module, then there is no mobile DNAPL in the area. Not much rebound occurs with flooding (which does not mean there is not plenty of residual). Flooding as a technique has a well-defined basis for shutting the system off.

Question: Can you use coring to locate DNAPLs?
Answer: Cores themselves will generally not have any evidence of DNAPL presence. You might see the DNAPL in the return water but use of drilling fluids tends to flush DNAPL out of fractures in the core.

Question: Do you ever heat the water used for flooding?
Answer: Generally no. If you are strictly trying to remove the mobile phase, heating just increases the cost.

Continuing DNAPL Mobility at MGP Sites: A New York Perspective Jim Cummings, U.S. EPA, Technology Innovation Office

Jim Cummings summarized a presentation prepared by the New York State Department of Environmental Conservation on their investigations of the mobility of coal tar DNAPL at former manufactured gas plant (MGP) sites. There are over 300 MGP sites in New York—most located near surface water bodies. The MGP gas holders, the main sources of DNAPL contamination, were pressurized and had leaky foundations. As a result, they acted like large hypodermic needles injecting coal tar below the water table. Oil contamination is typically present at MGP sites because it was often added into the coal tar to enhance its BTU. The addition of oil also enhanced the mobility of the coal tar by creating an emulsion.

MGP coal tars are not as viscous as would be expected because they are derived from petroleum and contained added oil. The DNAPLs are neutrally buoyant and may be present as emulsions. Off-site DNAPL plumes are common and can be quite large. Seven of the 60 MGP sites undergoing remedial investigation in New York have plumes greater than 300 feet in length. The New York MGP sites show evidence of continuing DNAPL mobility with continuing discharges to surface water bodies and induced movement into excavations and wells. Residual saturation can also result in movement of DNAPL. Mr. Cummings showed examples of sites where tidal lifting is drawing NAPL into surface water bodies and where vibration of a drill rig caused NAPL to migrate beneath the pavement and into surface water bodies, as evidenced by sheens emanating from the shoreline.

The potential for exposure to the DNAPL to humans exist when underground utility workers have direct contact with coal tar seeps or inhale the vapors. NAPL discharges to surface water is the primary ecological exposure route. The PAH content of the coal tars are highly toxic to benthic organisms in the sediment.

Mr. Cummings cautioned that investigations of MGP sites should consider the potential large impact of small sites and how small scale geologic features (e.g., sand seams or bedrock joints) often control mobility. Thus borehole logging should be done carefully. Furthermore, the potential for sediment contamination and migration via the surface water pathway should be investigated.

To view Mr. Cummings' presentation materials for details, click here.

Ground-Water Remediation at DNAPL Sites
Jim Cummings, U.S. EPA, Technology Innovation Office

Jim Cummings summarized some of the available technologies for cleaning up DNAPL and the obstacles that must be overcome to advance the science behind these cleanups. Although 60-70% of sites on the NPL have been contaminated with NAPL, most available ground-water remediation methods address the dissolved phase plume and not the NAPL. Mr. Cummings described pump and

treat as simply a protracted containment remedy that will incur very expensive operations and maintenance costs for decades or even longer.

There are several alternative technologies to pump and treat that have been applied successfully at NAPL sites. Steam enhanced extraction to remove creosote at the Visalia Wood Treater NPL site was shown to significantly reduce concentrations of creosote and pentachlorophenol in ground water at the site. The comparative costs and estimated removal times were significantly less than for conventional pump and treat. SPH, which can be used in low permeability lithologies, also has been used to remove NAPL from sites with removals cited as high as 99.9% of cleanup goals. In addition, in situ oxidation is finding widespread use in removing NAPL at UST sites and dry cleaner sites.

An important consideration in NAPL cleanups is whether enough of the source area mass can be removed to allow meaningful risk reduction and meaningful reduction in pump and treat/MNA timeframes for residual plume polishing. Mr. Cummings emphasized the need to determine the mass flux in addition to mass reduction in order to improve cleanups. The underlying science, empirical knowledge base, and regulatory framework behind NAPL cleanups all need to be addressed further. Mr. Cummings concluded by saying the goal of this work should be adequate use of robust source term removal technologies, a timely transition to cost-effective polishing steps, a reduction or even elimination of the need for pump and treat, and an *appropriate* reliance on MNA.

To view Mr. Cummings' presentation materials for details, click here.

RESEARCH UPDATES

Contaminated Sediment Research

Dr. Dan Reible, HSRC/S&SW at Louisiana State University

Dr. Dan Reible, Director of the Hazardous Substance Research Center/South and Southwest (HSRC/S&SW), presented an overview of the center's research activities and capabilities. HSRC/S&SW is a competitively awarded, peer-reviewed, research consortium led by Louisiana State University with the cooperation of the Georgia Institute of Technology, Rice University, and Texas A&M University whose mission is to address critical hazardous substance problems, especially as they relate to contaminated sediments. The center was established in 1991 under CERCLA to conduct research and technology transfer designed to promote risk-based management and control of hazardous substances for the nation and EPA Regions 4 and 6. The center also conducts regional outreach that is driven by community interests and problems.

The contaminated sediments and dredged materials of concern contain organics (such as PCBs, PAHs, and petroleum hydrocarbons), metals (such as arsenic, lead, and cadmium), and conventional pollutants. These environmental contaminants are either suspended in the water column or stored on the bottom of rivers, bayous, lakes, harbors, estuaries, freshwater wetlands, and in ocean waters of the continental shelf.

Research themes at the HSRC/S&SW include:

- assessing the physical, chemical, and biological processes influencing contaminant availability;
- evaluating and enhancing biotransformation processes in sediments; and
- improving the science of risk management for contaminated sediments.

Dr. Reible explained that contaminated sediments are difficult to remediate because they reside in highly variable, dynamic systems with incomplete exposure pathways and uncertain risks. The large volume of sediment and water that must be processed at a typical site also contributes to the high cost and complexity of the projects. It is important to clean up contaminated sediments because they present a significant impediment to the unrestricted usage of waterways, as well as posing a threat to the health of the aquatic ecosystem. The problem is also widespread—roughly 30% of all Superfund sites involve contaminated sediments. The Gulf Coast and inland waterways served by the HSRC/S&SW contain some of the nations' most important harbors and rivers, and is home to 54% of the nation's wetlands. This area is also frequently impacted by large storm events that tend to resuspend sediment, potentially releasing contaminants back into the water.

HSRC/S&SW has extensive analytical, field assessment, and biological assessment capabilities. The center is also developing specialized computer programs that can be used to model chemical transport and fate. HSRC/S&SW is currently working on four primary core research programs: contaminant losses during sediment resuspension by removal or storm events; phytoremediation of wetland and CDF sediments; bioavailability of desorption resistant contaminants; and in-situ containment and treatment of contaminated sediments. In addition, the center is conducting studies aimed at characterizing cap effectiveness using x-ray adsorption near edge spectroscopy (XANES) and x-ray tomography (XRT). The center's biotechnology initiative seeks to enhance fundamental understanding and practical application of biological systems for remediation of environmental contaminants and treatment of environmental wastes.

For more information on the HSRC/S&SW, you can visit their website at www.hsrc-ssw.org.

To view Dr. Reible's presentation materials for details, click here.

Anacostia River Capping Update

Dr. Dan Reible, HSRC/S&SW at Louisiana State University

Dr. Reible provided an update on the status of the Anacostia River capping project that the HSRC/S&SW is managing. The Anacostia River is a freshwater tidal system that drains an urban watershed that encompasses 456 square km in Maryland and the District of Columbia. Sampling has revealed elevated concentrations of PCBs, polynuclear aromatic hydrocarbons (PAHs), lead and other trace elements, and pesticides. This site was chosen for a number of reasons, including the presence of documented areas of sediment contamination, the unique opportunity to work with a citizens group (Anacostia Watershed Toxics Alliance), and the stability of the system. The project objective is to demonstrate and validate the comparative effectiveness of traditional and innovative capping methods relative to control areas under realistic, well-documented, in-situ conditions at the site.

The project involves establishing a grid of capping cells in two locations that are approximately 200 ft by 500 feet adjacent to the shoreline. Each cell will be approximately 100 feet by 100 feet in size. The first site is located near an old CSO outfall, while the second is near an old manufactured gas plant. Five technologies are undergoing bench-scale testing and evaluation: Aquablok ™, zero-valent iron, apatite barrier, BionSoil™, and OrganoClay Sorbent. Before the end of December, the team hopes to have developed a site characterization workplan, distributed the workplan for review and comment, initiated site characterization, reported preliminary conclusions on laboratory treatability studies, completed the preliminary field construction design, and coordinated with the EPA's Superfund Innovative Technology Evaluation (SITE) program. The SITE program intends to focus their efforts on the effectiveness of Aquablok in terms of placement and seepage control. The site characterization objectives are to establish the contamination baseline at demonstrated areas, determine the

geotechnical characteristics of the sediment, and provide necessary baseline data for future evaluation of capping placement and capping technologies.

A two-staged sampling approach is planned for site characterization. Stage 1 will be implemented in 2002 to provide a representative assessment of demonstration site conditions and to provide necessary information to refine the subsequent sediment coring and benthic community sampling. Stage 2 sampling will be implemented in the spring of 2003 to accommodate the biological parameter sampling such as submerged aquatic vegetation (SAV) and benthic community due to reduced biological activities in the winter season as well as provide opportunity for supplemental sampling to respond to issues raised during stage 1.

Additional information on this topic can be found at www.hsrc-ssw.org.

Questions and Answers

Question: Are you concerned about scouring from the river?
Answer: We are trying to assess whether or not riverflow scouring will be a problem. The flow velocity of the Anacostia River is relatively slow compared to many other rivers. The biggest danger to the cap is ship traffic, which thankfully is also sparse at this point in the river. The top of the cap could be armored should it be determined that scouring or boat traffic poses a threat.

Question: Is there any concern about gas accumulation under the cap?
Answer: Yes, we have some concern about gas accumulation or NAPL migration under the cap. We will monitor for gas and other contaminants. Gas is most likely to be trapped under the Aquablok.

Question: How common are contaminants in this river?
Answer: The Anacostia River is a classic contaminated urban stream. There has been no significant cleanup of the river, so many source areas still exist.

Question: Does the HSRC collaborate with USACE?
Answer: While financial collaboration is minimal, the two organizations do collaborate on technical issues informally.

Question: Is 1.5 years an adequate time period to determine the affect of the caps on the biota?
Answer: We expect recolonization in two seasons. One and a half years is enough time to see trends. We expect to continue monitoring the site for longer than 1.5 years.

Question: Will other environmental problems (e.g., outfalls, source areas) be cleaned up in the near future?
Answer: At present, there are no plans to clean up the Anacostia River. That is one reason that we are able to conduct this pilot study. We expect sediment on top of the cap to be recontaminated from external source areas, but the sediment beneath the cap should not experience recontamination.

To view Dr. Reible's presentation materials for details, click here.

Energy Conservation and Production at Waste Cleanup Sites

Katarina Mahutova, U.S. EPA, Region 10 Visiting Scholar

Katarina Mahutova announced the availability of the draft Energy Audit Issue paper for review. Ms. Mahutova drafted the issue paper with additional input from GeoTrans, Inc. Ms. Mahutova also thanked Mike Gill (HSTL, Region 9), Kelly Madalinski (TIO), and Ed Mead (USACE) for their contributions to the draft. She asked that the forum members read the draft and provide feedback by January 24, 2003.

The issue paper highlights the importance of energy efficiency in the design of remedial systems. Different technologies have different energy needs, and green power energy production can be done in several ways. Energy can be produced at many waste cleanup sites, such as the combustion of methane at landfill remedial sites, the installation of photovoltaic solar arrays, and the generation of power from garbage incineration. There are also opportunities to conserve energy at cleanup sites, including pilot test sites. The issue paper discusses these opportunities and explains how to finance energy efficiency improvements at waste cleanup sites.

The issue paper presents two case studies of energy production at landfills in California and two case studies on potential energy conservation at pump and treat sites in GeoTrans' optimization study. The case studies show that the pump and treat systems are over-designed and do not use energy efficient pumps and motors. The cost savings recognized through energy savings using energy efficient equipment can be used to pay for improvements to the pump and treat systems.

Ms. Mahutova concluded her presentation by mentioning the three types of measures that will be used to promote the concept of energy conservation and production at waste cleanup: communications, administrative, and economic. Communications efforts include the issue paper, conferences, and a webpage. Administrative measures include developing tools and guidance for evaluating energy efficiency, and incorporating the tools into remedial decision/remedial action, 5-year review, and optimization guidance. Economic measures include Energy Saving Performance Contracts and incentives for project managers and contractors.

Mike Gill will e-mail a copy of the draft issue paper to those forum members wishing to review it. In the future, he would like to produce a guide that summarized how to conserve energy for five or six cleanup technologies and conduct a webcast to raise awareness on these issues.

Questions and Answers

Question: Do you plan to put an energy audit requirement in 5-year reviews?
Answer: No.

To view Ms. Mahutova's presentation materials for details, click here.

Update from the Engineering Technical Support Center

Marta Richards, U.S. EPA, National Risk Management Research Laboratory, Cincinnati, OH

Marta Richards updated the forums on the current research being conducted by EPA's Engineering Technical Support Center in Cincinnati. In FY02, ETSC staff assisted with 379 site actions at 106 different sites in all 10 EPA Regions (A site action is defined as an event in the site history that encompasses more than 8 hours of a staff person's time and/or travel.). Of these 106 sites, 89 were Superfund sites, 14 were RCRA sites, 2 were brownfields, and 1 was an Office of Water site. In

addition, all ETSC staff worked on site demonstrations. Regions 9 and 4 accounted for the most number of site actions that ETSC assisted with, while Regions 10 and 7 accounted for the least number of sites. ETSC expects to assist with over 400 site actions in FY03. A large percentage of the site actions that the center assisted with were classified as mining sites. Landfills, wood treatment sites, oil waste, and chemical/manufacturing sites were also popular. The center expects that the number requests for assistance at brownfields, landfills, and oil/oil waste sites will increase next year. Passive treatment (mostly used at mining sites), stabilization/solidification, and thermal desorption were the three most common technologies employed at FY02 ETSC site actions. Information on most of these sites can be accessed trough the site technical assistance reporting system (STARS).

Ms. Richards reported that mining technical support has increased over the past two years, a trend that is expected to continue with the heightened awareness of the thousands of abandoned hard rock mines and with the inclusion of mine-scarred lands in the definition of brownfields. The ETSC also expects more landfill actions in FY03. The most popular landfill issues include physical instability, capping alternatives, phytoremediation, seismic stability, long term performance (5-year reviews), and bioreactors. Ms. Richards also noted a need for guidance on some of these issues.

Ms. Richards said that as more experienced engineers leave the Agency or retire, the technological knowledge of RPMs diminishes. Dave Reisman (ETSC Director) is on a workgroup that is investigating the development of an applied training program. The RCRA/Corrective Action Program is also developing internet-based training modules. Ms. Richards concluded by noting that homeland security issues as they relate to contaminated wastes will likely become more important following the creation of the Office of Homeland Security. Other "hot" topics for the coming years include landfill gases escaping from sites, the Johnson & Ettinger model, vapor intrusion guidance application at sites, houses/schools on site borders, and site reuse issues.

FIELD TRIP TO NAVAL SCHOOL AND MCKINLEY CLIMATIC LABORATORY, EGLIN AIR FORCE BASE

Overview of Naval School

Following a welcome from Lt. Commander J. Polanin, Warrant Officer Rex Rousseau provided an overview of the Naval School, Explosive Ordnance Disposal (NAVSCOLEOD) Command unit operating at Eglin Air Force Base. Under Navy management and funding, NAVSCOLEOD is staffed jointly by the Navy, Army, Air Force, and Marine Corps. The Technical Training Acceptance Board, which also is jointly operated, approves the school's curriculum and implements decisions concerning its explosive ordnance disposal (EOD) training program. NAVSCOLEOD is attended by students from all U.S. military branches and selected federal agencies and by military students from 72 countries. Over 400 students currently attend the school.

The NAVSCOLEOD training approach addresses the fundamental skills required for EOD handling in the field, including ordnance identification, tool familiarity, approach/disassembly safety, reconnaissance, disposal, and information management. Combined EOD skills address various families of ordnance (including conventional, improvised, biochemical, nuclear, and radioactive devices) that may be deployed in the air, on the ground, or underwater. Training addresses aspects of ordnance neutralization, including the use of robotics and associated sensors, protective gear, and visualization systems. The school's training ranges can accommodate devices ranging from 1.5 to 1,000 pounds in net explosive weight.

Basic EOD training for Army, Marine Corps, and Air Force participants lasts approximately 6.5 months; additional training is provided to Navy students for approximately 3.5 months. Two-week courses in advanced EOD management and advanced access/disablement are offered by the NAVSCOLEOD detachment at Indian Head, MD.

Questions and Answers

Question: Are any efforts made by NAVSCOLEOD to transfer EOD knowledge to academic institutions?
Answer: Information sharing between NAVSCOLEOD and academia occurs through the school's occasional retention of academic experts.

Question: How is environmental compliance handled at the facility?
Answer: NAVSCOLEOD compiles relevant environmental data weekly and provides the information to SAIC (support contractor) yearly. The primary data systems used by the facility are the Munitions Items Disposition Action System Database (MIDAS) and Toxic Release Inventory/Data Delivery System (TRI-DDS). Collected data elements regarding ordnance use include the ordnance type, ordnance quantity, deployment date, and utilized range. In addition, detonation noise volumes are predicted through modeling and publicized in the community the day prior to detonation.

Question: Is any basic, non-classified guidance available to help workers quickly identify potential ordnance in the field?
Answer: Efforts will be made to identify materials that may useful for this purpose, and if available, they will be forwarded to an EPA representative for distribution.

Question: Does NAVSCOLEOD interact with air ordnance organizations at military installations?
Answer: Although NAVSCOLEOD does not extensively interact with base-specific ordnance groups, it does maintain detachments at major Navy units located in key locations such as China Bay.

Question: Has the school experienced any major accidents during training sessions?
Answer: No major accidents have occurred during the school's existence.

Following Warrant Rousseau's overview, NAVSCOLEOD staff provided a tour of the training facilities and demonstrations of selected training equipment.

To view Warrant Officer Rousseau's presentation materials for more details, click here.

Overview of McKinley Climatic Laboratory

The McKinley Climatic Laboratory, formerly known as the "Climatic Hangar," began operating in 1947 as a refrigerated airplane hangar building designed to test military aircraft and equipment under cold-weather conditions. Due to an increasing need to evaluate the performance of aircraft parts under extreme climatic conditions, the facility has expanded over the years to allow for testing under a wide range of variables.

The laboratory currently is operated by the Air Force Systems Command. Its facility at Eglin Air Force Base houses six test chambers, one of which is the largest in the world (with capacity to accommodate any U.S. military or commercial aircraft). Climatic variables tested at the laboratory include temperature (from -80 to 170°F), rain (up to 15 inches/hr), wind (up to 60 knots), altitude (up to 80,000 ft), solar radiation, humidity, snow, icing, clouds, and sand/dust, as well as non-climatic factors stress factors such as salting, electricity, and gunfire.

Approximately 65-70% of the tests conducted at the McKinley Climatic Laboratory are performed on military subjects, including aircraft, ancillary equipment, weaponry, and shelters. Commercial testing (of primarily aircraft and ground vehicles) accounts for the remaining portion of the laboratory's services.

Following an audio/video presentation, laboratory staff provided a "hot-weather" tour of the laboratory's main chamber. Additional information on the laboratory is available at www.eglin.af.mil.

NOVEMBER 21, 2002

RADIATION TRAINING

Glenn Kistner (Region 9) welcomed participants to the radiation training being provided to attendees of the TSP meeting. The training session, which also served as the participants'8-hour OSHA refresher course, was developed by radiation experts and health physicists from EPA/Region 9 and EPA/Cincinnati's Emergency Response Team (ERT), including Steve Dean (Region 9) and Gerald Gels (Veridian Corporation), contractor to ERT.

Introductions and Basic Radiation
Steve Dean, U.S. EPA Region 9

Mr. Dean introduced the training session by explaining various types of radiation, modes of nuclear decay, ionizing radiation, kinetic energy, radionuclide decay, sources of (natural and man-made) radiation, radionuclide background concentrations in soil, and personal radiation dose.

To view Mr. Dean's presentation materials for more details, click here.

Additional information also is available from the EPA's Office of Air and Radiation publication, *Ionizing Radiation Series, No. 1: General Description* (ANR-459, September 1990).

Radiation: Units of Measure and Health Effects
Gerald Gels, Veridian Corporation

Mr. Gels discussed key units of radiation measurement and health effects from radiation exposure. Discussion elements included ionization density, absorbed dose, dose equivalents, effective dose equivalents, organ weighting factors, occupations commonly associated with radiation exposure, dose-effect relationships, sources of ionizing radiation exposure, acute/fatal radiation effects, and occupational exposure limits. An important "rule of thumb" stressed that field exposure to any suspected emitter of alpha radiation requires the use of protective gear for workers and high-particulate filters for sampling equipment. It was noted that the (limited) studies on risks posed by depleted uranium (U^{235}) indicate relatively low levels of radioactivity are associated with the material. As a result, workers exposed on military ranges to depleted uranium munition rounds are subjected to radioactivity levels significantly lower than those associated with uranium mass.

To view Mr. Gels's presentation materials for more details, click here.

Additional information also is available from the EPA/Office of Air and Radiation publication, *Ionizing Radiation Series, No. 2: Health Effects from Exposure to Ionizing Radiation* (ANR-459, June 1991).

Radiation Myths and Legends
Steve Dean, U.S. EPA Region 9

Forum members were treated to clips from several science fiction movies from the 1950s, including "Them!," "It Came from Beneath the Sea," and "Beginning of the End." In each of these films, radiation (from atomic explosions and atomic testing on plants) mutates seemingly harmless creatures into house-sized monsters that destroy everything in their path. The films fueled misconceptions about

the dangers of radiation when they were released in the post-World War II era. "Radiophobia" has lessened somewhat over the years as the general population has become more informed about and accustomed to the benefits of nuclear energy. Radioactive mutants have evolved from destructive monsters to folk heros. The greatest radiation myth that has perpetuated to this day is that plutonium is the deadliest substance on earth, when in fact it isn't even one of the ten most carcinogenic substances. (Cobalt 60 is the most carcinogenic). More education and public outreach are needed to dispel radiation myths and legends.

To view Mr. Dean's presentation materials for more details, click here.

Naturally Occurring Radioactive Material (NORM) vs. Manmade Radionuclides

Gerald Gels, Veridian Corporation

Gerald Gels differentiated between and provided examples of the different types of environmental radioactivity: primordial, terrestrial, natural chain, cosmogenic, and manmade. Cosmogenic radiation contributions to natural background increase with elevation and are much higher during solar flares. Exposure to terrestrial radioactivity ranges as high as 5mR/hr in places in Brazil and India where monzanite sands are present due to Thorium 232, Radium 226, and their progeny. There are a number of useful manmade radioisotopes, including those used for medical purposes and other industrial or consumer purposes such as static eliminators, smoke detectors, and food sterilization.

Mr. Gels noted that the term "TENORM," or technologically enhanced and naturally occurring radioactive material, is now commonly used. TENORM includes materials such as radium contained in pipe scale, radon in the effluent from SVE units, indoor radon, and Cesium 137 in wood ash from the burning of trees that took up radioactive fallout materials.

To view Mr. Gels's presentation materials for more details, click here.

Analytical Methods for Soil and Ground Water

David Saunders, U.S. EPA, National Air and Radiation Environmental Laboratory, Montgomery, AL

David Saunders explained some of the common analytical techniques for radionuclides, including gamma spectrometry using a high purity germanium spectrometer, gross alpha and beta analysis using proportional counters, beta-specific analyses using proportional counters, alpha spectrometry, and liquid scintillation counters. He summarized the how each technique operates and the advantages and disadvantages associated with the techniques. He took participants on a "virtual tour" of the National Air and Radiation Environmental Laboratory to explain its capabilities.

Mr. Saunders summarized some issues associated with filtering and preserving ground-water samples for radioisotopes analyses. Filtration is a project-specific decision and depends on project DQOs. EPA's Science Advisory Board Report (1997) recommends low-flow sampling without filtration for metals analysis. For metallic radionuclides, preservation with nitric acid is required to prevent loss, although acid preservation is not recommended for the analysis of tritium, Technicum-99, Radon-222, etc. Acid can break up these radionuclides and dissipate some of the radiation. If filtration is required, preservatives should be added after filtration to avoid leaching from the solids. Mr. Saunders provided a flow chart for selecting the appropriate analytical methods to use for ground water, given the site-specific radionuclides present.

Mr. Saunders concluded his presentation by summarizing the status of the *Multi-Agency Radiological Laboratory Analytical Protocols Manual*, or MARLAP. The MARLAP manual, which is a guidance manual for project managers, planners, and radioanalytical laboratories. Agency review comments have been incorporated, and the manual is currently being revised to include public and peer comments. It will be available in final form in Fall 2003.

To view Mr. Saunder's presentation materials for more details, click here.

Simulating Radionuclide Fate and Transport in the Unsaturated Zone

Rob Earle, U.S. EPA, National Risk Management Research Laboratory, Ada, OK

Rob Earle described a sensitivity analysis conducted using five computer models that simulate flow and transport through the unsaturated zone at the Las Cruces Trench Site in New Mexico. The model results were compared to site analytical results. Ranging from simplest to most complex, the five representative models chosen for the analysis were CHAIN, MULTIMED-DP, FECTUZ, HYDRUS, and CHAIN 2D. Mr. Earle detailed the capabilities and limitations of these models and stressed the importance of understanding the input parameters and interpreting the model output.

The sensitivity analysis used the Process Parameter Sensitivity Technique to test the five models. The technique is designed to explore changes in model output for a discrete unit change in each model input. For each varied input, all the other model inputs were held at nominal or baseline values. The input parameters tested included the distribution coefficient, recharge rate, soil water content, bulk density, dispersivity, and van Genuchten retention parameters. The breakthrough curves for the radioactive contaminants were then analyzed, which involved testing the following outputs: peak concentration, the time for the peak concentration to reach the water table, and the time for the chemicals of concern to exceed the MCL at the water table.

Mr. Earle provided the assumptions used for all five of the models and summarized the conclusions drawn from using each model. He indicated that the CHAIN model is a good "first choice" model to use as a screening tool. He concluded by providing links to useful websites for further information modeling flow and transport in the unsaturated zone.

To view Mr. Earle's presentation materials for more details, click here.

Soil Vapor Extraction (SVE)/Radon Measurements at McClellan Air Force Base

Gerald Gels, Veridian Corporation

Gerald Gels briefed forum members on the radon samples that he took near an SVE unit at McClellan Air Force Base in California. Radiation was being emitted from activated carbon in a dozen active SVE units. The purpose of the study was to determine the doses that personnel working in nearby buildings were being exposed to annually. The team measured radon being emitted from the stack and used a computer model to estimate annual exposure rates. Using a RAD7 instrument, the team tested all operating SVE units using 5-minute counts. They completed 4-5 cycles at each stack. Using meteorological data from Sacramento airport and a modified Gaussian plume model, the team calculated dose and risk from radionuclide emissions to air using CAP88-PC software. Of the 13 unites tested, .92 mrem/yr was the dose returned, which is well below the study threshold of 10 mg/yr. Mr. Gels and his team felt comfortable that the radiation exposure rate to people working in nearby buildings was below threshold values and would not adversely affect their health.

To view Mr. Gels's presentation materials for more details, click here.

Questions and Answers

Question: How was regeneration of the carbon canisters handled?
Answer: The spent carbon was disposed as hazardous waste.

Dirty Bombs/Radiation Dispersal Devices

Steve Dean, U.S. EPA Region 9

Radiation can be dispersed with either a nuclear device (atomic bomb) or a radiation dispersal device, or "dirty bomb." Dirty bombs generally consist of radioactive materials packed around a conventional explosive device, such as TNT. The radioactive materials can come from a number of sources, including nuclear medicine materials and radiological equipment. The harmful effects of a dirty bomb are extremely limited when compared to those resulting from the detonation of a traditional nuclear device. Fallout, blast effects, and thermal heat from a dirty bomb depend on the size of the conventional explosion and the type and grade of radioactive material used. Generally, a dirty bomb constructed using industrial or medical sources of nuclear material would only devastate an area a few city blocks in size.

In the past, low-grade nuclear materials have not been difficult to purchase or salvage. In fact, "orphaned" radioactive sources—a term utilized by nuclear regulators to denote radioactive sources that are outside official regulatory control—are a widespread phenomenon in the newly independent states (NIS) of the former USSR. U.S. companies have lost track of nearly 1,500 radioactive sources within the country since 1996, and more than half were never recovered. Following the events of September 11, 2001, and the subsequent hunt for terrorist cells around the world, the international community is much more aware of potential sources of radiation, and an multinational effort is underway to account for vast quantities of missing nuclear material.

To view Mr. Dean's presentation materials for more details, click here.

Mare Island Naval Shipyard Dredge Pond Blobs

Steve Dean, U.S. EPA Region 9

Dredge ponds cover approximately 467 acres of Mare Island Naval Shipyard in the San Francisco Bay Area. The shipyard used to manufacture and maintain nuclear submarines and other Navy vessels. During their routine navigation dredging activities, the Navy pumped dredge spoil to ponds on the west side of the island. Metallic debris, generally consisting of materials that were dumped off ships, were trapped in the dredge spoil and transported to the dredge ponds, where they sank to the bottom in large piles. The metals precipitated to form blobs that rusted. Numerous radium devices were discovered embedded in the blobs when they were broken up in search of unexploded ordnance. Most of these devices were illuminators, or "cats eyes," that were used to illuminate companionways and staircases about Navy vessels. Cleanup crews also found radium covered ropes that served a similar purpose. The blobs were broken up, the metal inside recycled, and the radium sent to Utah for disposal. After a $200 million cleanup, the site is now 99.9% clean and is slated for redevelopment.

To view Mr. Dean's presentation materials for more details, click here.

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